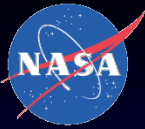
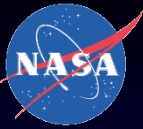


Agenda



10:05am	IMM Overview	D. Butler
10:15am	Clinical Methods	E. Kerstman
10:25am	Resources	L. Saile
10:30am	Case Scenarios	C. Minard
10:50am	Discussion	All



The Integrated Medical Model

A Decision Support Tool for In-flight Crew Health Care

Presenter: Doug Butler

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(281) 212 -1380

**Presentation to the Human Systems Integration
Knowledge Broadcast Series**

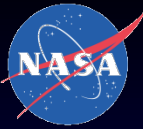
NASA Johnson Space Center/SD4

Wyle Integrated Science and Engineering Group

Houston, TX

26 May 2009

IMM Project Goals



- To develop an integrated, quantified, evidence-based decision support tool useful to crew health and mission planners.
- To help align science, technology, and operational activities intended to optimize crew health, safety, and mission success.

Scope and Approach



IMM addresses in-flight risk only, and uses ISS data as stepping stone

- Scope
 - Forecast medical outcomes for in-flight operations only
 - Forecast medical impacts to mission
 - Does not assess long-term or chronic post-mission medical consequences
- Approach
 - Use ISS data as stepping stone to Exploration Program
 - Employ best-evidence clinical research methods
 - Employ Probability Risk Assessment (PRA) techniques
 - Collaborate with other NASA Centers and Organizations

What is IMM?

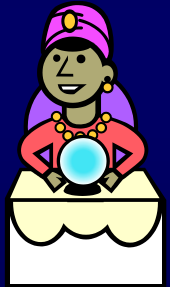


- A software-based decision support tool
 - Forecasts the impact of medical events on space flight missions
 - Optimizes the medical system within the constraints of the space flight environment during simulations.

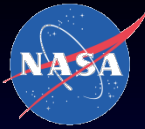


Software is used across a wide range of industries to represent stochastic, probabilistic processes and uncertainty

- Crystal Ball Software (Oracle Corp.)
 - Commercially available software application
 - Microsoft Excel user interface
 - Stochastic forecasting and optimization
- SAS (Statistical Analysis Software)
 - IMM 1.0 currently transitioning to SAS due to large number of variables in the model



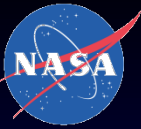
HSI and Program Benefits



- How does a decision support tool like IMM aid a Program that's just forming?
 - Knowledge Management
 - Objectivity
 - Prioritization
 - Rationalization
 - Optimization
 - Communication

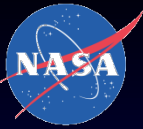


Who can benefit from IMM capabilities?



- Flight Surgeons
 - What in-flight medical threats are greatest for reference mission A?
- Risk Managers
 - What is the risk of evacuation - due to a medical event - for a 6-person, 180 day mission assuming the current in-flight medical capability?
- Vehicle Designers
 - What's the optimum medical mass allocation for given level of risk?
- Health Care System Designers
 - What medical items do we fly for a given mass/volume allocation?
- Trainers
 - How do I prioritize limited crew training hours?
- Requirement Managers
 - What's the rationale for this crew health requirement?

“What if...?” Questions



*IMM is designed to help answer **specific in-flight questions***



Questions

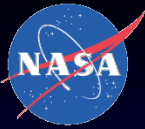
- Is the current ISS medical kit adequate for a crew of 6 on a 6-month mission?
- Does a 33-day lunar sortie mission require a different Level of Care than a 24-day lunar sortie mission?
- Are we carrying enough Ibuprofen for a crew of six on a 12-month mission?
- How does risk change if the ventilator fails at the start of a 3-year mission?



Questions

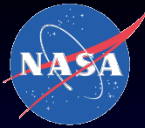
- What is the probability of a bone fracture occurring 10-years after a 6-month mission?
- What is the probability of renal stone formation after a 12-month mission?

When does IMM prove useful?



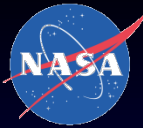
IMM supports decisions at all program phases





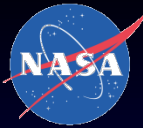
- IMM Inputs
 - Rationale for ISS Medical Kit Redesign
 - List of Prioritized Medical Conditions by Reference Mission
 - Requirements rationale for vomitus and diarrhea
- IMM Outputs
 - ISS Risk Model Medical Updates - Pending

Risk Vocabulary



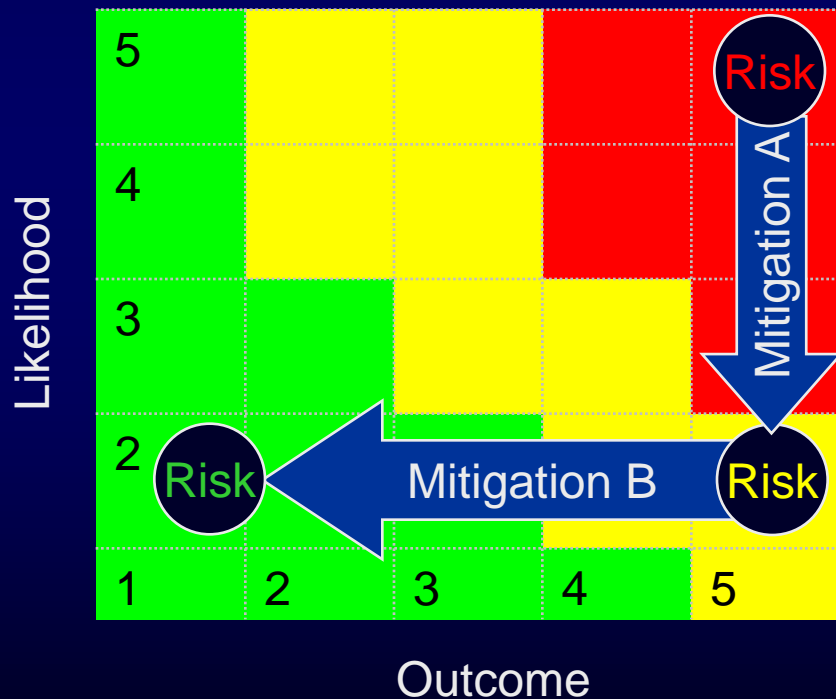
Common Risk Management Terms	IMM
<ul style="list-style-type: none">• Hazard• Threat• Initiating event	<ul style="list-style-type: none">• Medical condition experienced by the crew in flight
<ul style="list-style-type: none">• Likelihood	<ul style="list-style-type: none">• Probability of a medical event
<ul style="list-style-type: none">• Consequence• Outcome• End State	<ul style="list-style-type: none">• Evacuation• Loss of Crew Life• Crew Health Index (CHI)
<ul style="list-style-type: none">• Control• Mitigation	<ul style="list-style-type: none">• In-flight capability to diagnose and treat the medical event

Risk and Risk Components



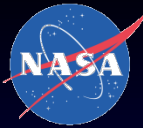
“Risk” is what’s left over after you’ve accounted for likelihood, outcome, and the mitigation associated with the threat.

5x5 Matrix for Threat Z



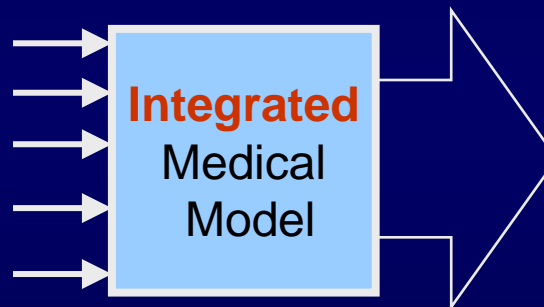
5x5 Matrix	IMM
Likelihood (Score 1-5)	Medical Condition Incidence
Mitigation?	In-flight Medical Capabilities
Outcome (Score 1-5)	Crew Functional Impairment
Risk Score (2x1) for a single “risk”	Impact to mission due to all medical conditions for the crew compliment

IMM Conceptual Model



INPUTS

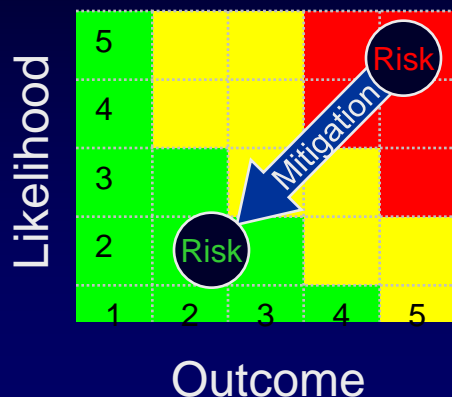
- Medical Conditions & Incidence Data
- Crew Profile
- Mission Profile & Constraints
- Potential Crew Impairments
- Potential Mission End states
- In-flight Medical Resources



OUTPUTS

- Medical Condition Occurrences
- Crew Impairments
- Clinical End States
- Mission End States
- Resource Utilization
- Optimized Medical System

Comparison – 5x5 Risk Matrix vs. IMM



5x5 Matrix

- Qualitative
- Categorical
- Subjective
- Single Risk
- No Uncertainty
- No Confidence Interval
- Limited context

IMM

- Quantitative
- Probabilistic, Stochastic
- Evidence-based
- Integrated Risks
- Uncertainty
- Confidence Interval
- In context

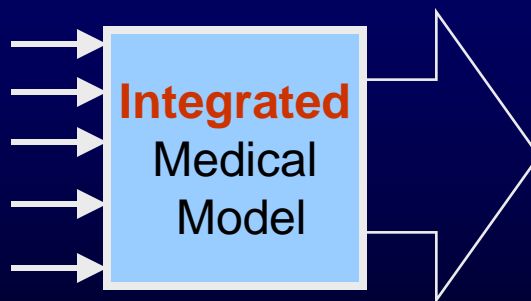
▪ Medical Conditions & Incidence Data

▪ Crew Profile

▪ Mission Profile & Constraints

▪ Crew Functional Impairments

▪ In-flight Medical Resources



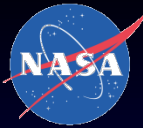
▪ Medical Condition Occurrences

▪ Crew Impairment & Clinical End States

▪ Resource Utilization

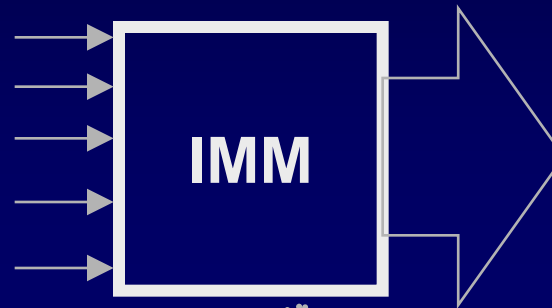
▪ Optimization of Vehicle Constraints and Medical System Capabilities

IMM Logic



INPUTS

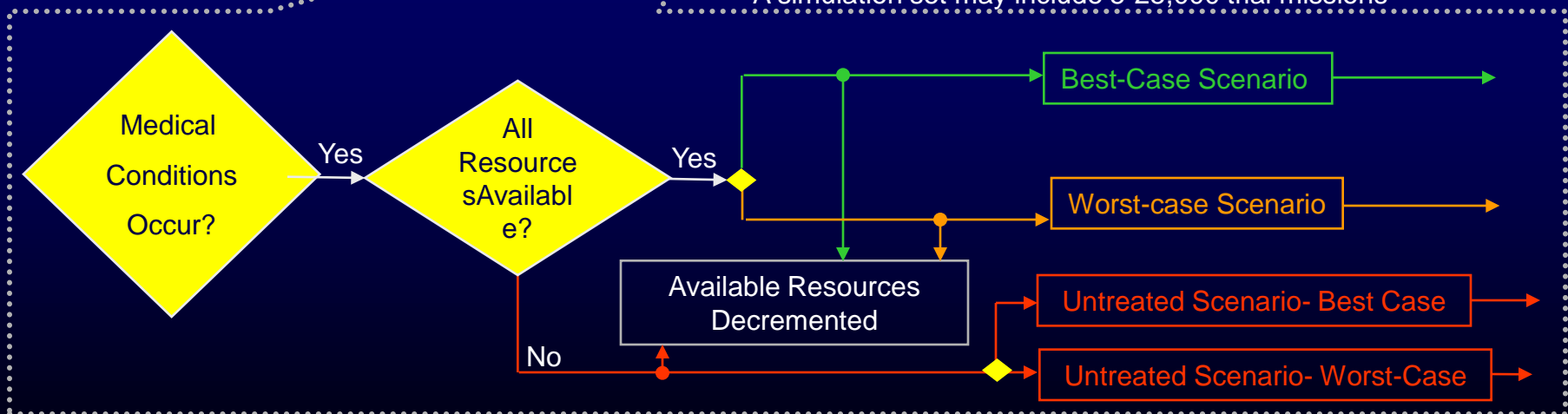
- Medical Conditions & Incidence Data
- Crew Profile
- Mission Profile & Constraints
- Potential Crew Functional Impairments
- Potential Mission End States
- In-flight Medical Resources



OUTPUT of Distributions

- Medical Condition Occurrences
- Crew Impairment
- Clinical End States
- Mission End States
- Resource Utilization
- Optimized Medical System

A simulation set may include 5-25,000 trial missions

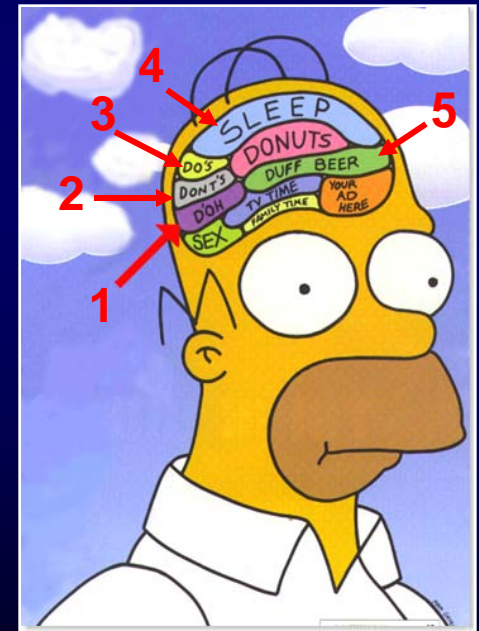


IMM Logic



For each comparative assessment, the identical questions are asked 5,000+ times to develop outcome distributions

1. Did the medical condition happen?
2. How many times?
3. Best or worst-case scenario?
4. Were resources available?
5. What was the outcome?



Key Development Steps



Each step is in the critical path

- Develop a Conceptual Model
- Create initial list of relevant medical conditions
- Characterize incidence data
- Quantify crew impairment and clinical end states
- Quantify resources needed to diagnose and treat
- Develop a quantified Crew Health Index
- Understand implications of assumptions
- Verify & Validate
- Refine & Maintain Data



Development Status

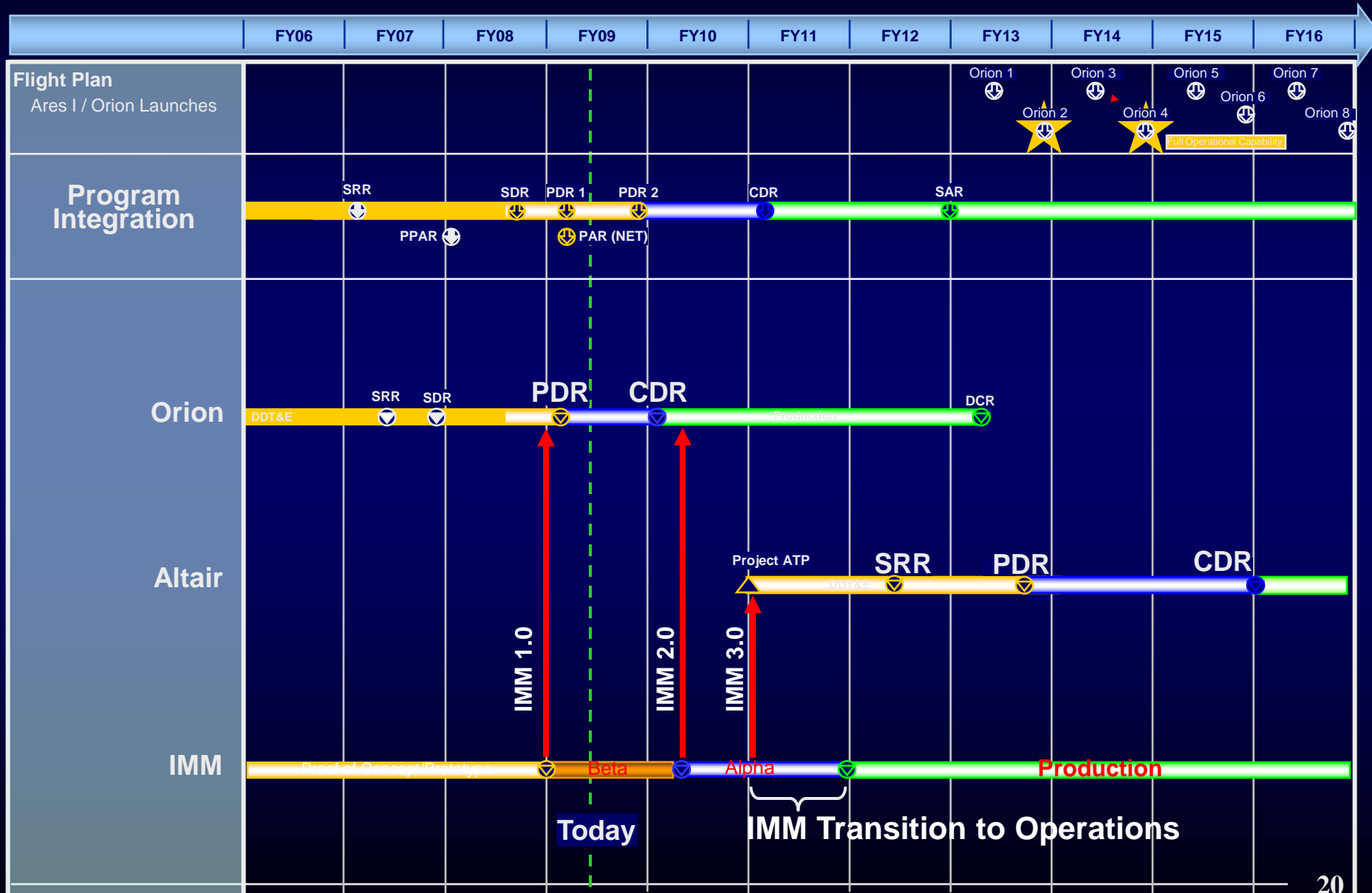


- Current Status of Model
 - First version of IMM 1.0 completed (Sept 2008)
 - IMM 1.0 supports assessments of 1-6 crew members
 - 83 medical conditions represented
 - 47 of 83 medical conditions have been recorded to occur in flight
 - Medical Resources (type, quantity, mass, volume) per condition
- Capabilities
 - Forecasts medical condition occurrences
 - Identifies medical conditions that most influence crew impairment and mission impact
 - Identifies key contributors to crew impairment and clinical outcomes (e.g. depleted or lack of in-flight medical resources)
 - Compares crew health risk between different missions



IMM Development vs. Constellation Program Schedule

PMR '08 Rev 1 – As of 03/31/09



Next Steps



- Work in Progress
 - Transition to SAS software platform
 - Optimization Algorithm Implementation
 - Database Development & Integration
 - Internal Verification & Validation
- Next 12 Months – Key Milestones
 - Develop database user interfaces
 - Develop IMM 2.0
 - Initiate external Verification & Validation
 - Communication to stakeholders
 - Prepare for transition to operations

Closing

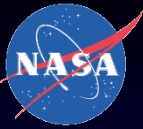


IMM addresses the observations documented by the RTF Task Group

***...experience and instinct are poor substitutes for
careful analysis of uncertainty...***

***...This requires that analytical models be used
appropriately to inform decisions...***

*(Source: NASA Return to Flight Task Group Final Report: Annex A.2
Individual Member Observations by Dr. Dan L. Crippen, Dr. Charles C.
Daniel, Dr. Amy K. Donahue, Col. Susan J. Helms, Ms. Susan Morrissey
Livingstone, Dr. Rosemary O'Leary, and Mr. William Wegner.)*



IMM Clinical Methods and Inputs

Presenter: Eric Kerstman M.D., M.P.H.

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Outline

- Development of the Medical Condition List (MCL)
- Overview of Incidence Determinations
- Functional Impairments
- Clinical Findings Form (CliFF)

Purpose

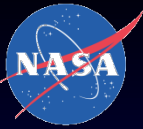
- To provide a list of medical conditions relevant to in-flight operations

Relevant Medical Condition

- Has occurred in flight or has the potential to occur in flight
- Requires mitigation and/or results in functional impairment

Current Status

- Consists of 83 medical conditions (47 have occurred in flight)



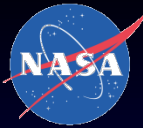
- **MCL Phase I**
 - ISS Medical Checklist (70 conditions)
- **MCL Phase II**
 - STS Medical Checklist (+1)
- **MCL Phase III**
 - Longitudinal Study of Astronaut Health (LSAH)
In-flight Medical Condition Occurrences (+6)
- **MCL Phase IV**
 - Flight Surgeon Delphi Study (+6)

LSAH

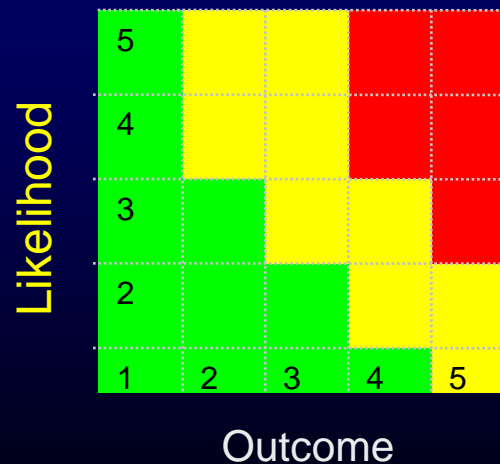
In flight Medical Condition Occurrences

- Includes Apollo, Skylab, Mir, Shuttle, and ISS
- STS-1 through STS-114 in 2005
- Expedition 1 through Expedition 13 in 2006
- 47 relevant medical conditions

The Use of Incidence



- Incidence is a measure of the likelihood of developing a medical condition
- IMM uses incidence to **quantify** the **likelihood** of occurrence of medical conditions in flight



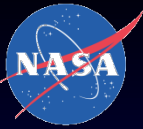
The number of new medical events that occur within a specified time period

Incidence Proportion (Cumulative Incidence)

- The proportion of a population who develop a medical condition within a specified period of time (events/person)

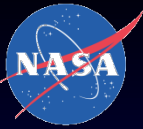
Incidence Rate (Incidence Density)

- The number of new medical events that occur within a population divided by the total time the population was at risk (events/person-year)
- Accounts for the different times that each individual was at risk

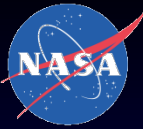


- Space Adaptation Syndrome (SAS)
- Non-Space Adaptation Syndrome

SAS Medical Conditions



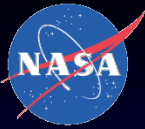
- 1) Back Pain
- 2) Constipation
- 3) Headache
- 4) Insomnia
- 5) Nasal Congestion
- 6) Nosebleed
- 7) Space Motion Sickness
- 8) Urinary Incontinence
- 9) Urinary Retention



- Likelihood of occurrence **is not** related to mission duration
 - Condition does not recur
 - **Incidence proportions** (events/person) are determined from LSAH in flight occurrence data
-

Example: Nasal Congestion

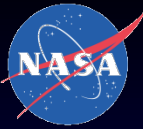
405 events among 660 persons = 0.614 events/person



- The likelihood of occurrence **is** related to mission duration
- Condition may recur
- **Incidence rates** (events/person-year) are determined from LSAH in flight occurrence data or other sources

Example: Skin Rash

90 events within 27.34 person-years = 3.29 events/person-year



Incidence Rate Determinations

Conditions that have occurred in flight

- LSAH in flight occurrence data

Conditions that have not occurred in flight

- External models (fractures)
- Environmental engineering data (altitude sickness)
- Terrestrial general/analog population data (appendicitis)
- Bayesian statistics for rare events (kidney stones)

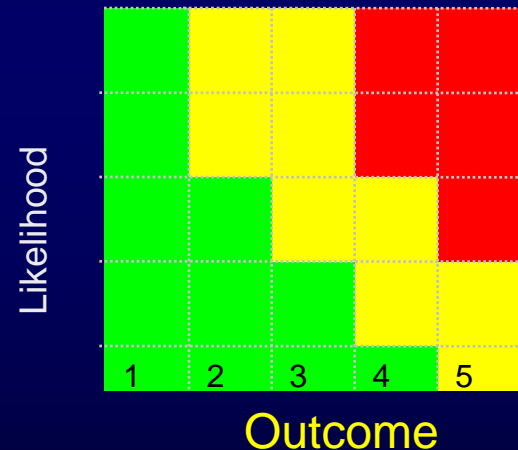
The Use of Functional Impairments



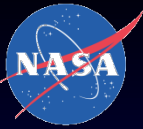
IMM uses the concept of functional impairments to **quantify** the severity of medical condition **outcomes**

Impairment

- A loss or loss of use of a body part, organ system, or organ function
- Considers both anatomic and functional loss
- Can develop from an illness or injury



American Medical Association Guides to the Evaluation of Permanent Impairment



Impairments

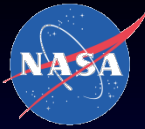
- Percentages that reflect the severity of the medical condition
- No impairment = 0 percent
- Fully dependant/approaching death = 100 percent

Examples

Skin Infection = 10 to 24 percent impairment

Shoulder Dislocation = 36 to 74 percent impairment

Clinical Findings Form (CliFF)



Standardized Format for IMM Clinical Inputs

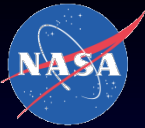
The likelihood of occurrence of the medical condition

- Incidence proportion or incidence rate

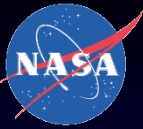
The clinical outcomes of the medical condition

- Considers ISS-based best case, worst case, and untreated case scenarios
- Specifies functional impairments and duration times
- Specifies potential end states (evacuation, loss of crew life)
- Specifies levels of evidence for input data
- References sources of data

Summary



- Relevant list of medical conditions established
- Incidence data established for each medical conditions
- Crew functional impairments and end states (evacuation and loss of crew life) used to characterize impact due to medical events
- Standardized tool (CliFF) established for clinical inputs of likelihood and outcomes for each medical condition



In-flight Diagnosis & Treatment Resources

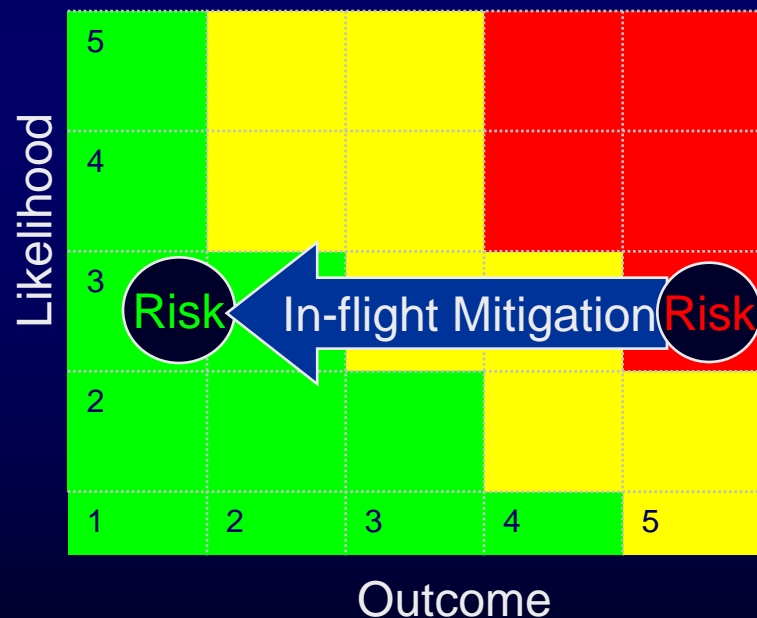
Presenter: Lynn Saile

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The resource tables (RT) define the in-flight medical resources

- Specifies the necessary resources for diagnosis
- Considers the treatment of best and worst case scenarios
- Provides input into IMM



Best and Worst Cases



Best Case Scenario

Consumable	Disorder: Musculoskeletal	Description	Quantity	Mass Kg GM		Volume cc3 mm3		Power (W)	Cost Estimates	COTS	Flight Certify	Sustaining Eng
1	Sprain/Strain Extremities	Ace Bandage	1	0.03875	38.75	442.5	442500			\$ 3.08		
		SAM splint	1	0.1134	113.4	1336.3575	1336357.5			\$ 12.00		
1		Acetaminophen	2	0.00036	0.36	0.02632	26.32			\$ 0.10		
1		Ibuprofen	1-9	0.00066	0.66	0.04202	42.02			\$ 0.14		

Worst Case Scenario

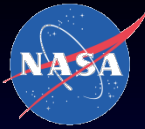
Consumable	Disorder	Description	Quantity	Mass Kg Gm		Volume cc ³ mm ³		Power	Cost Estimates	COTS	Flight Certify	Sustaining Eng
	Sprain/Strain Extremities	Ace Bandage	1	0.03875	38.75	442.5000	442500			\$ 3.08		
		SAM splint	1	0.1134	113.4	1336.3575	1336357.5			\$ 12.00		
1		acetaminophen (2 tabs*4-6hr)	8	0.00036	0.36	0.0263	26.32			\$ 0.10		
1		ibuprofen (1-2 tabs*8hr)	10	0.00066	0.66	0.0420	42.02			\$ 0.14		
1		Vicodin (1-2 tabs *4-6 hr)	2	0.00064	0.64	0.0483	48.30			\$ 0.50		
1		Gauze Pads	4	0.00504	5.04	7.6000	7600.00			\$ 0.16		
1		Nonsterile Gloves pr	1	0.014	14	3.1000	3100			\$ 0.10		
		Sharps container	1	0.59553	595.53	2909.1250	2909125.00		\$ 817.06			
1		20 G catheter	2	0.00622	18.51	7.5000	7500			\$ 0.15		
1		10cc syringe	1	0.01123	11.23	4.1700	4170			\$ 0.15		
1		Y-type catheter	1	0.00868	8.68	0.1000	100.00			\$ 0.50		
1		Tegaderm Dressing	1	0.00252	2.52	108.2000	108200			\$ 0.38		
1		Saline, 500mL	1	0.48929	489.29	750.8390	750839.00			\$ 10.81		
1		Iodine Pads	1	0.00108	1.08	0.1500	150.00			\$ 0.04		
1		Alcohol Pads	12	0.00108	1.08	0.1500	150.00			\$ 0.02		
1		Tourniquet	1	0.00603	6.03	5.0000	5000			\$ 0.24		
1		Tape	0.1	0.00906	9.06	6.4220	6422.00			\$ 0.11		
1		Morphine	1-10ml	0.00795	7.95	6.8855	6885.53			\$ 21.50		
1		carpuject	1	0.01524	15.24	5.6267	5626.67			\$ 5.01		

Resource Table Assumptions

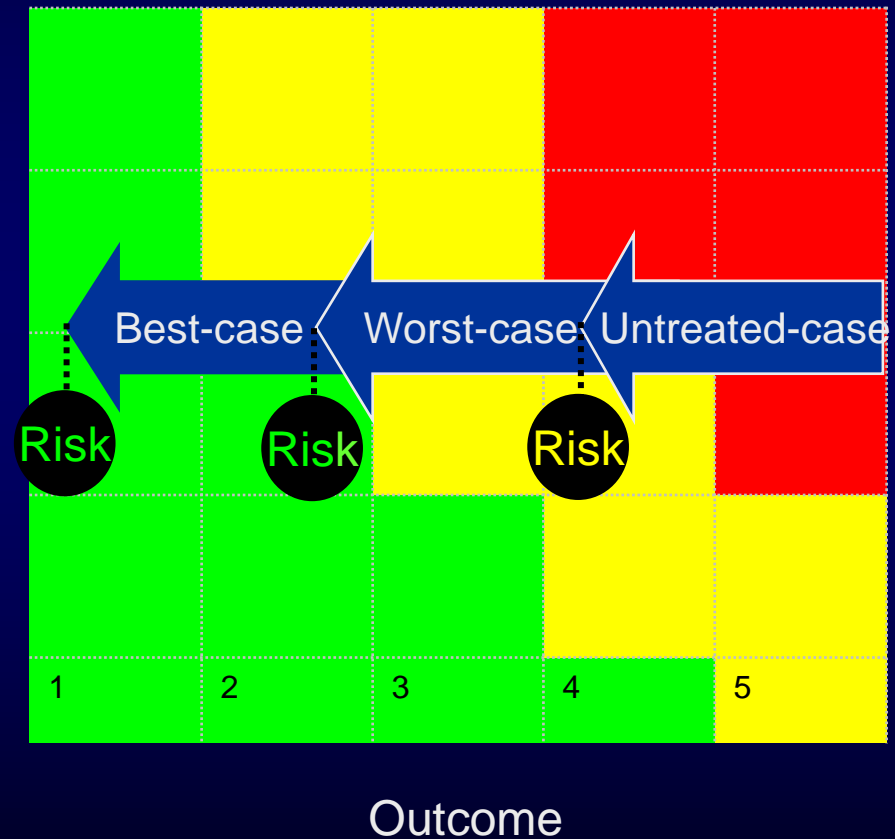


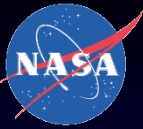
- The resource tables reflect the current ISS medical equipment, supplies, drugs, etc.
- Conditions go “untreated” when an “essential” item is not available (due to depletion or omission from the health care system)
- Cost information only includes Commercial-off-the-shelf (COTS)
- Spacecraft resources (e.g. oxygen, water, power, bandwidth) are not constrained

In-flight Mitigation



- Medical resources can be optimized for specific missions and crew profiles
- Resource tables identify the necessary supplies to mitigate risk by improving medical outcomes





Integrated Medical Model

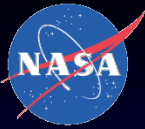
Outputs and Simulated Mission Scenarios

Presenter: Charles G. Minard, PhD

charles.g.minard@nasa.gov

281-461-2774

Integrated Medical Model



“Essentially, all models are wrong, but some are useful.”



George Box (1987)

Professor Emeritus of Statistics at the
University of Wisconsin

- IMM uses Monte Carlo simulation
 - Crystal Ball software
 - Microsoft Excel
 - Distribution of outcomes
- Probability distributions
 - Beta, Beta-PERT, Poisson, Bernoulli, Binomial, Lognormal, Uniform, Discrete uniform
- Crew Health Index (CHI)
 - Quality-adjusted mission time



Quality-Adjusted Mission Time



- Modification of quality-adjusted life years (QALY)
 - Standard epidemiologic measure
- Single, weighted measure of the net change in quality time

Example of QALY



- Consider the following individual:
 - 35 years old
 - 75 year life expectancy
- Medical event results in 30% functional impairment
 - Below knee amputation
- What is the QALY?

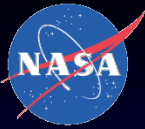
$$QALY = 40 - 40(0.3) = 40 - 12 = 28 \text{ yrs}$$

$$PQALY = \frac{28}{40} \cdot 100\% = 70\%$$

Crew Health
Index (CHI)

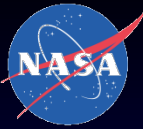
- With respect to IMM, “Life” is mission time

Crew Health Index (CHI)



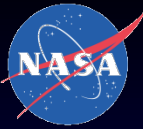
- Measure of crew performance
 - Ranges from 0 to 100%
 - 0% - completely impaired due to medical conditions for duration of mission
 - 100% - no impairment due to medical conditions

Key Model Assumptions



- 83 medical conditions
- ISS Health Maintenance System (HMS)
- Conservative estimate of Crew Health Index (CHI)
 - Medical events assumed to occur on the first day of the mission

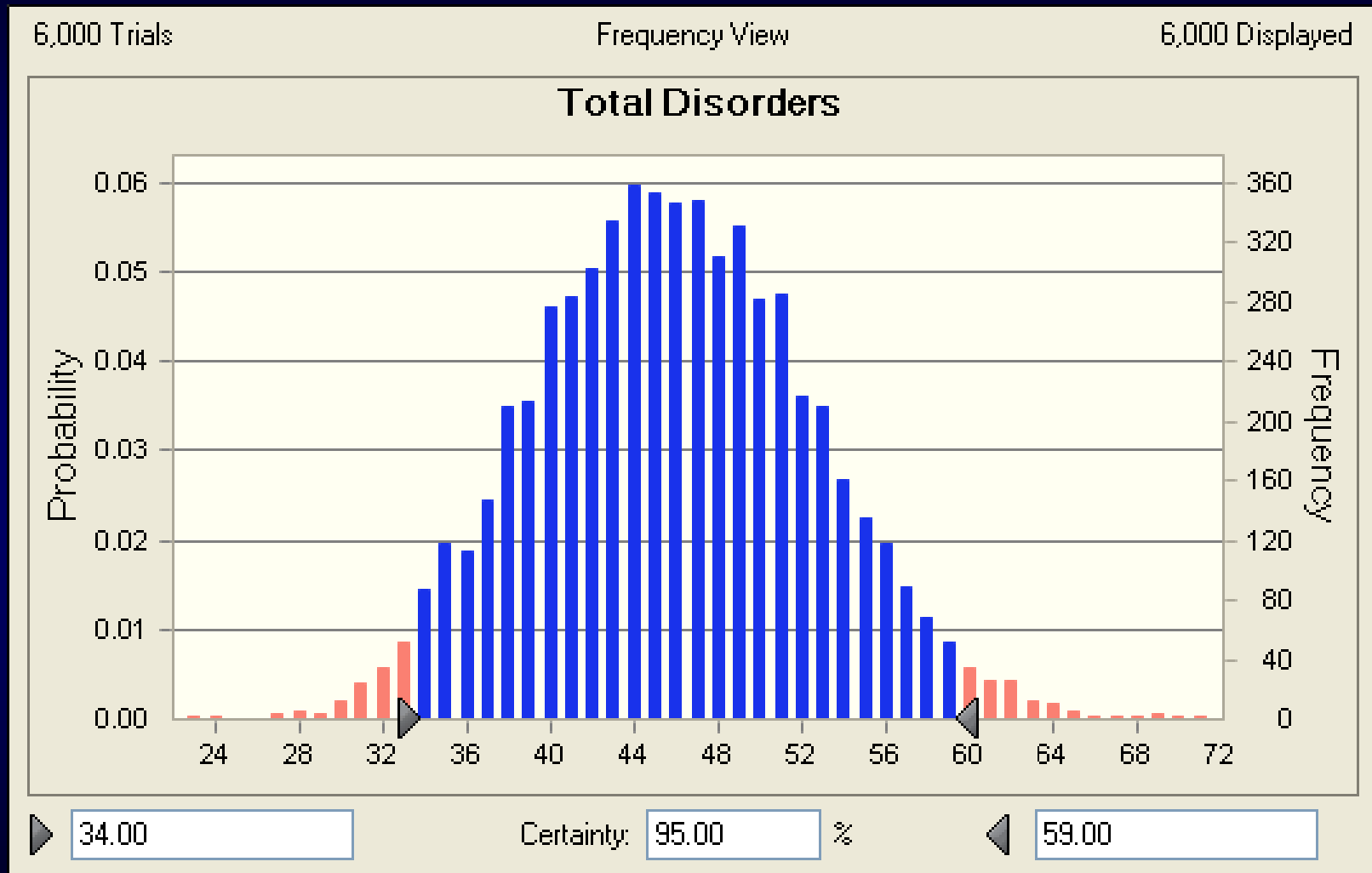
6 Month Mission



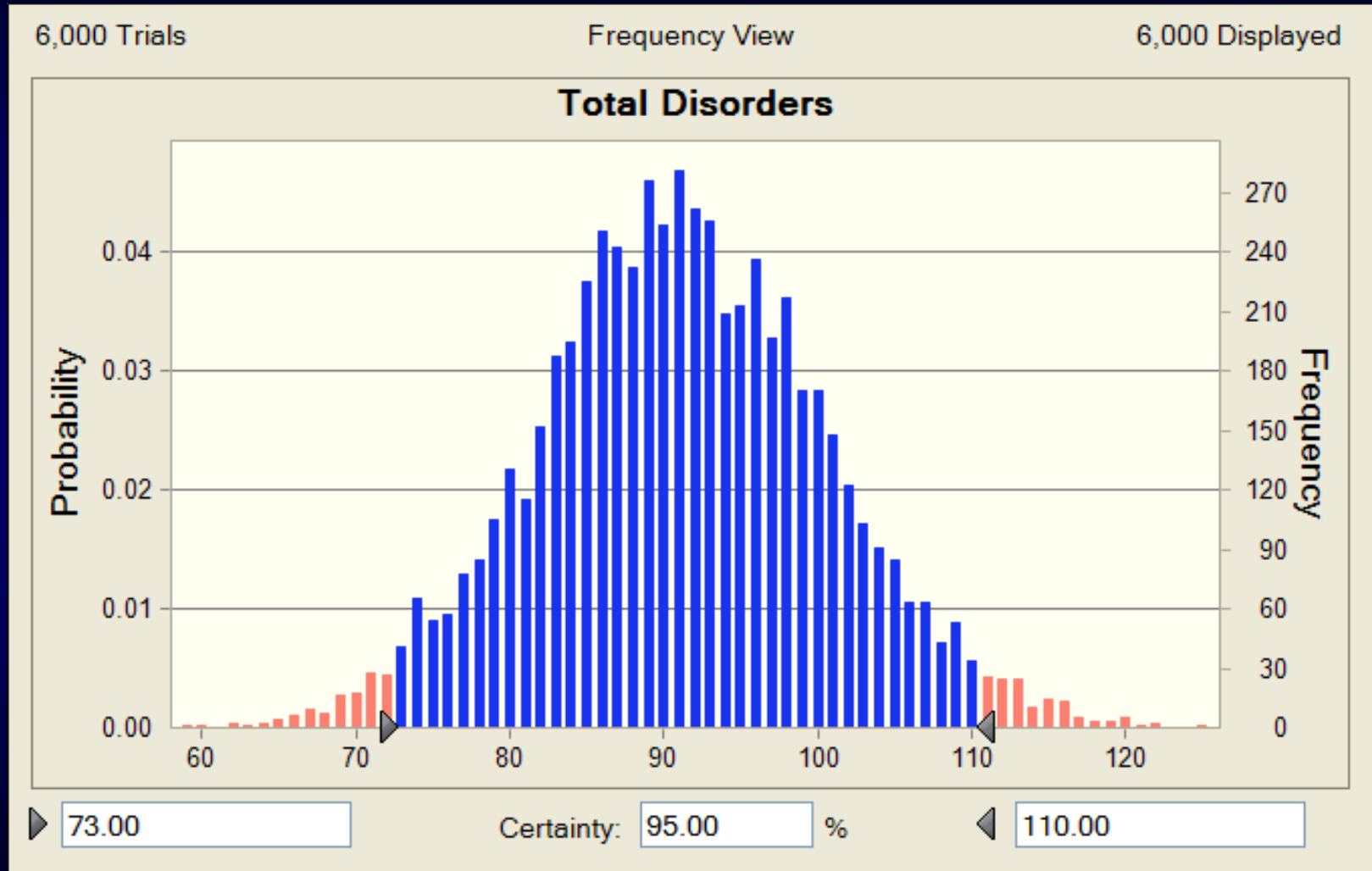
- Is the current HMS adequate for a 6 member crew?
- Consider two alternative 6 month missions
 - 3 crew members (2M,1F)
 - 6 crew members (5M,1F)
- 2 EVAs per crew member
- Identical medical resources (ISS)



Total Medical Events (3 Crew)



Total Medical Events (6 Crew)

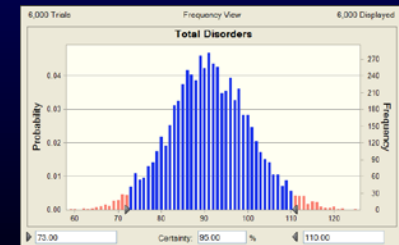
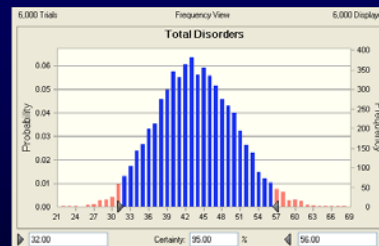


Total Medical Events

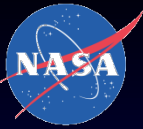


- Expect about twice as many medical events
- Expect greater variation in the number of events

Statistic	3 Crew	6 Crew
Mean	45.6	91.2
Median	46.0	91.0
SD	6.6	9.3
95% Inf.	34-59	73-110

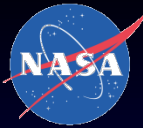


Sensitivity Analysis

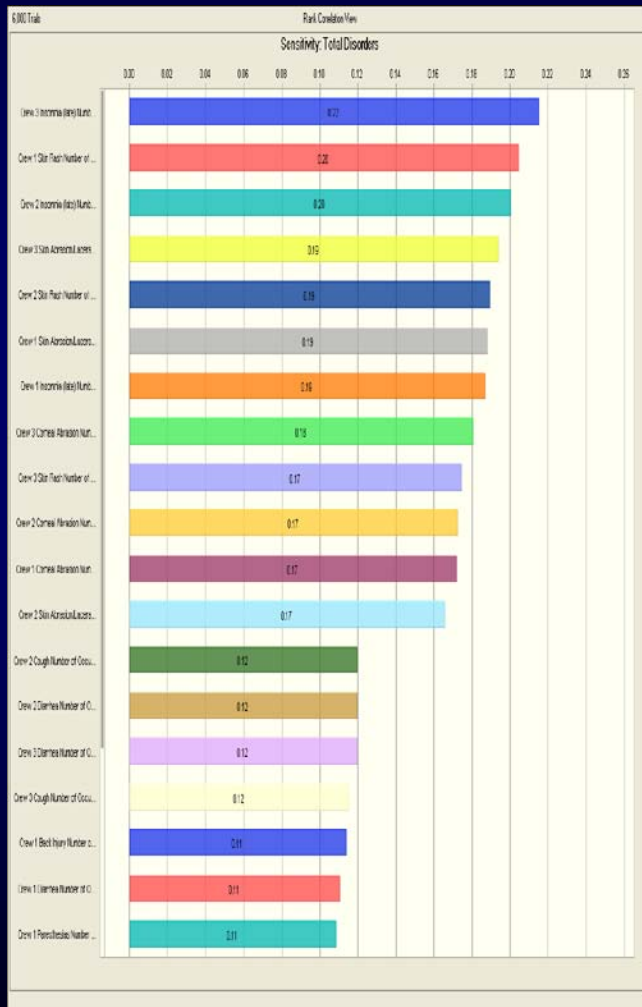


- What are the most influential factors?
 - Which variables describe the greatest variation in the distribution of the outcome?
 - Which variables are most highly correlated with the outcome of interest?

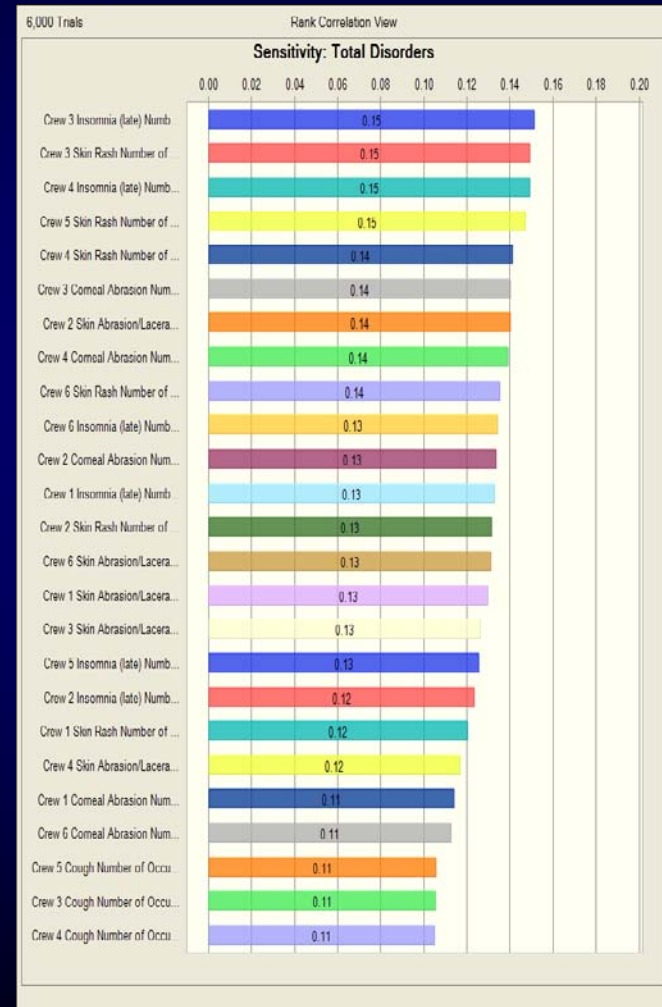
Sensitivity Analysis – Total Events



3 Crew Members



6 Crew Members



Sensitivity Analysis – Total Events



3 Crew Members

- 1) Late insomnia
- 2) Skin rash
- 3) Skin abrasion/laceration
- 4) Corneal abrasion

6 Crew Members

- 1) Late insomnia
- 2) Skin rash
- 3) Skin abrasion/laceration
- 4) Corneal abrasion

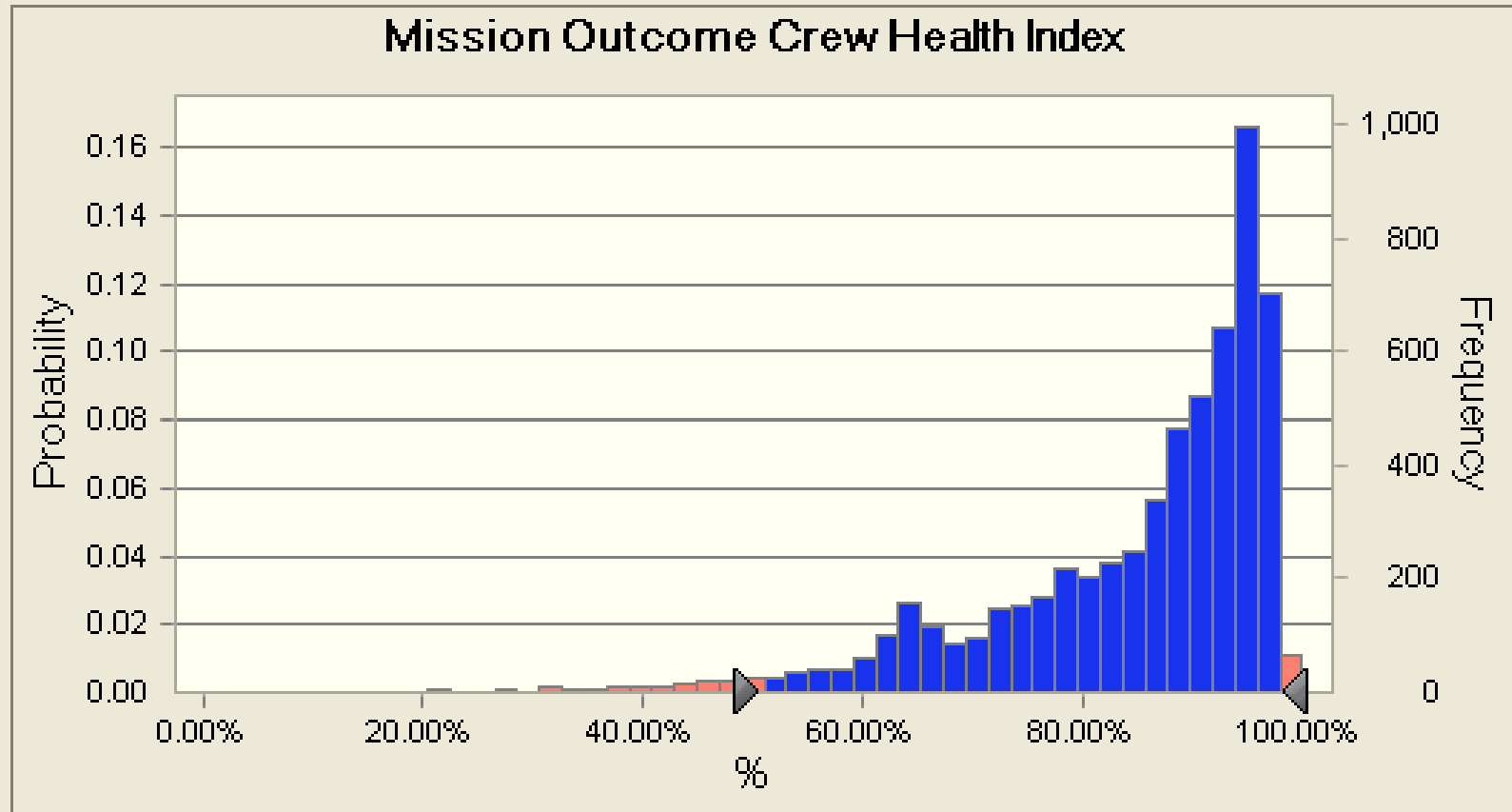
Crew Health Index (3 Crew)



6,000 Trials

Frequency View

6,000 Displayed

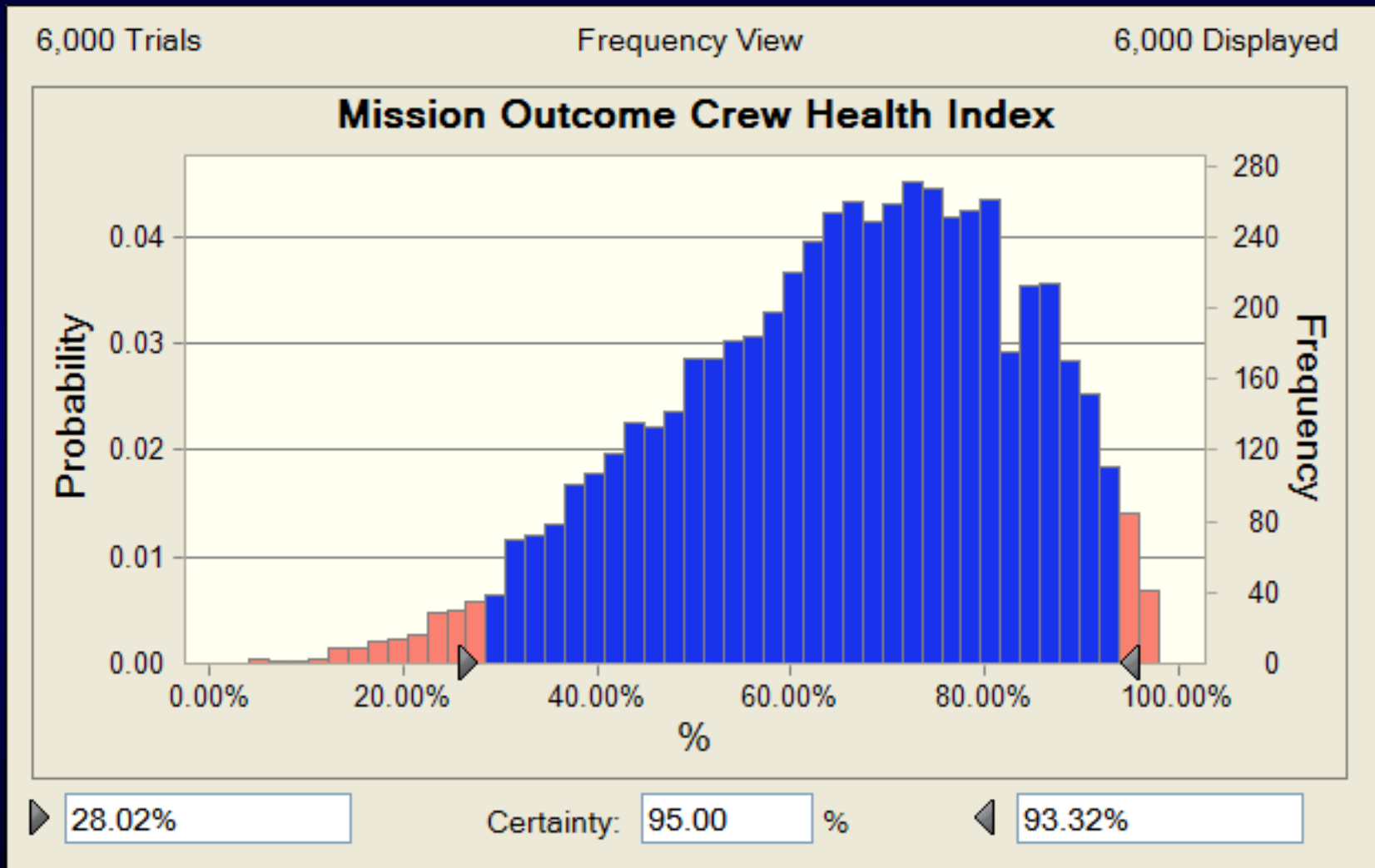


50.98%

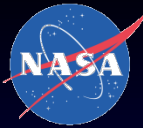
Certainty: 95.00 %

97.56%

Crew Health Index (6 Crew)

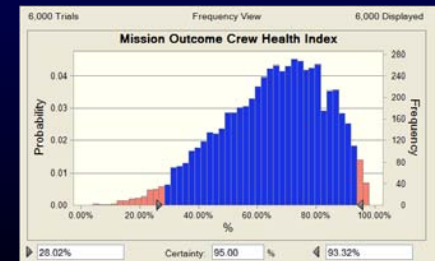


Crew Health Index

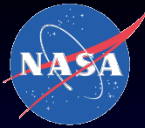


Statistic	3 Crew	6 Crew
Mean	84.8	65.3
Median	89.5	67.0
SD	13.0	17.6
95% Inference	51-98	28-93

- Expect decreased CHI with 6 crew members
- Expect greater variation



CHI Sensitivity Analysis



3 Crew Members

- 1) Skin rash
- 2) Cough

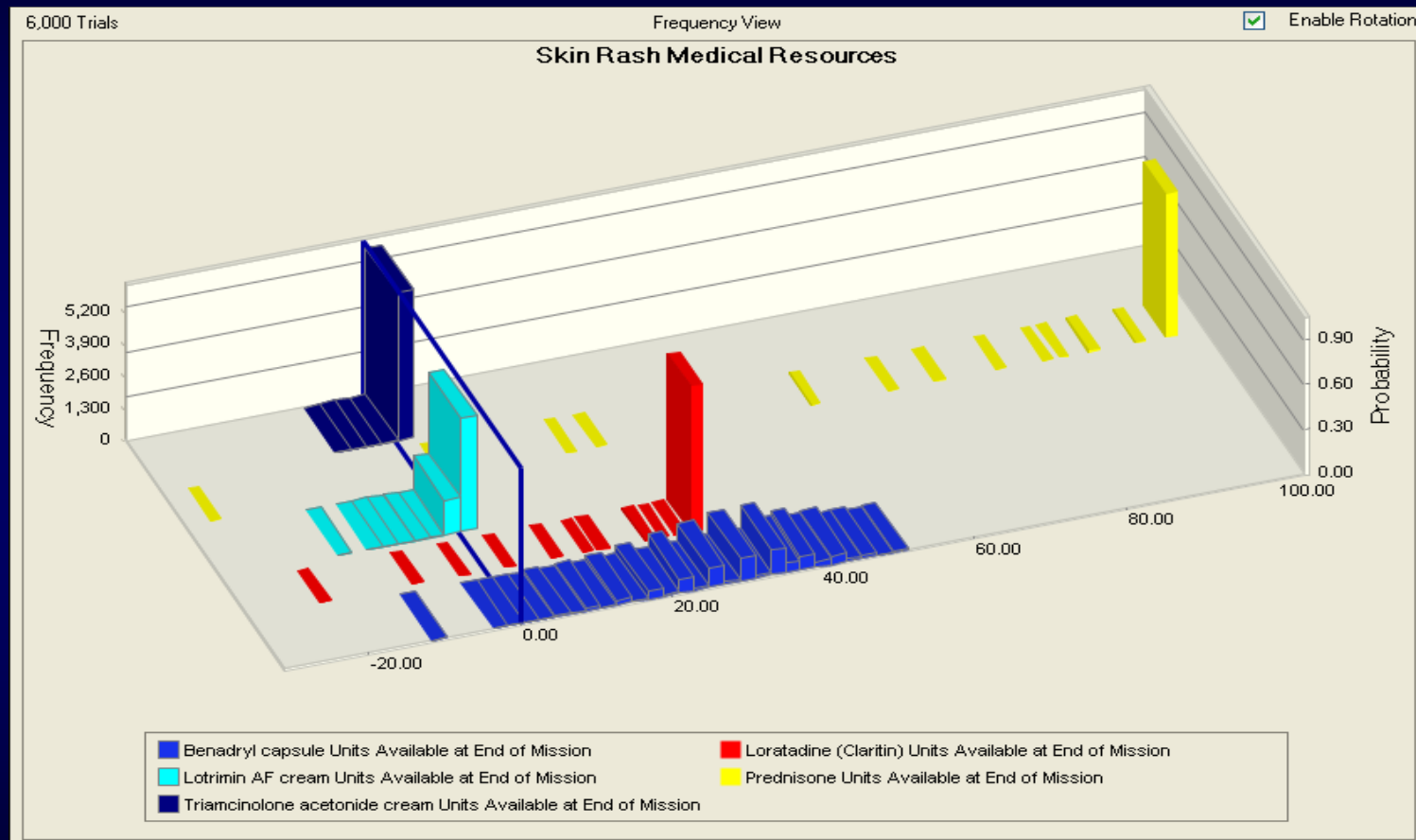
6 Crew Members

- 1) Skin rash
- 2) Paresthesia

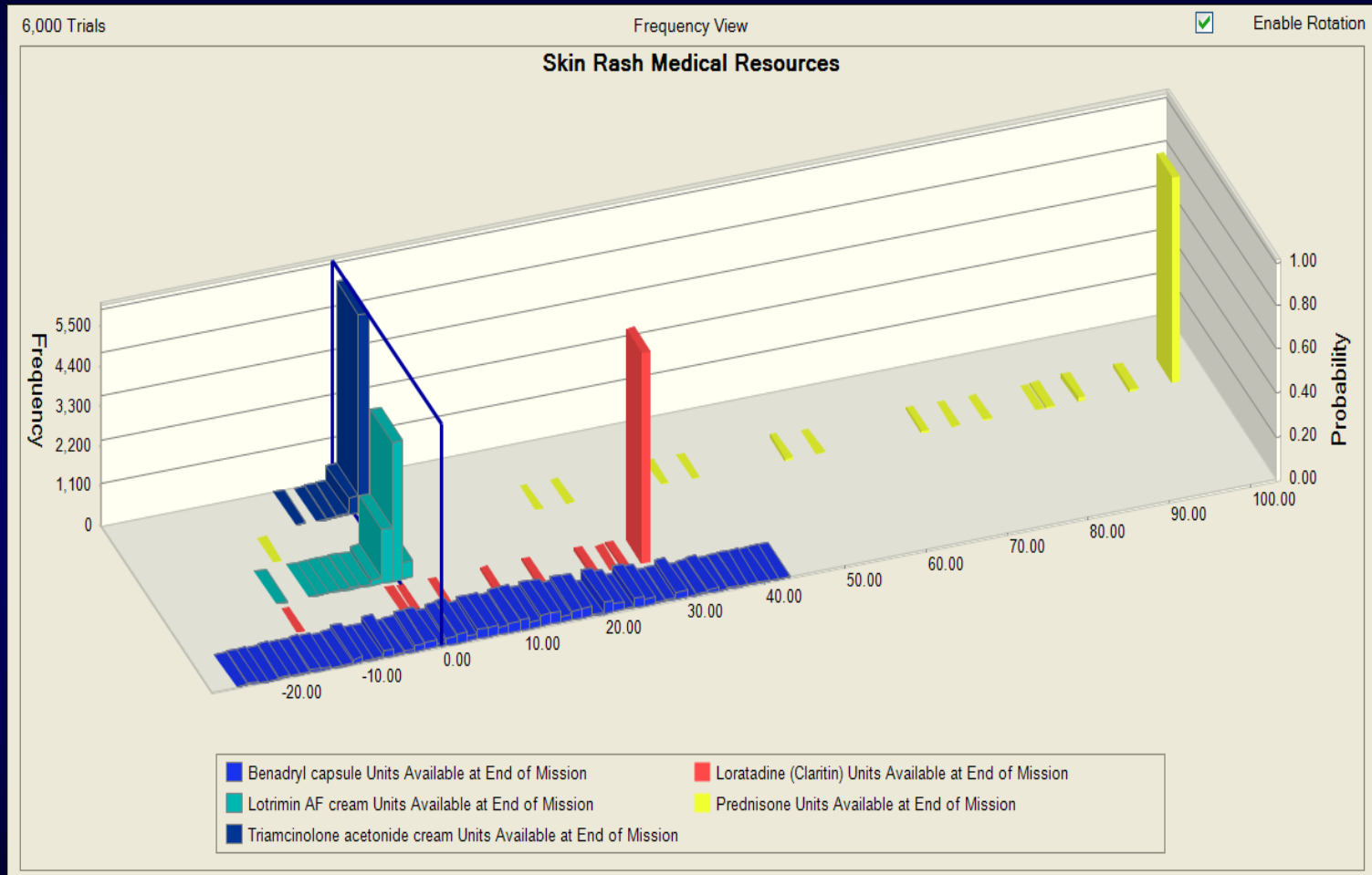
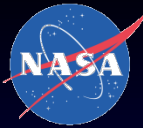
Why was the CHI decreased for 6 crew members?

- Consider medical resources for skin rash

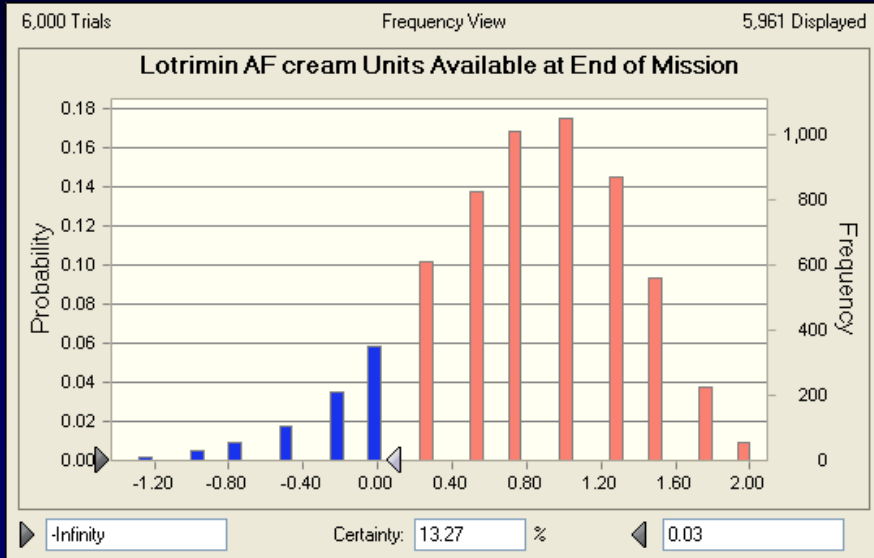
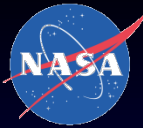
Skin Rash Resources (3 Crew)



Skin Rash Resources (6 Crew)

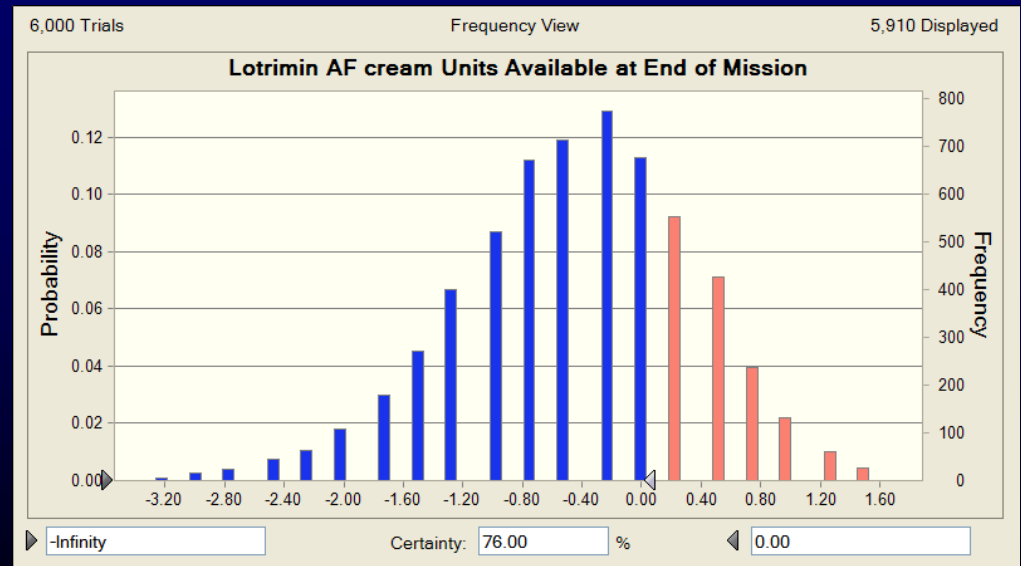


Lotramin AF

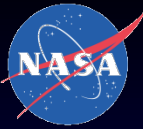


3 Crew Members
Insufficient for 13.3%
of the trials

6 Crew Members
Insufficient for 76.0% of
the trials

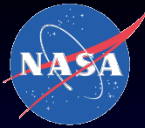


Summary



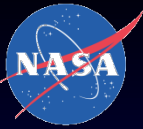
- Is the current ISS HMS adequate for a 6 member crew?
 - Substantial decrease in CHI with three additional crew members
- What conditions had the greatest impact?
 - Skin rash
 - Paresthesia
 - Corneal abrasions
- Why did skin rash impact the CHI?
 - Insufficient medical resources

Alternative Analyses



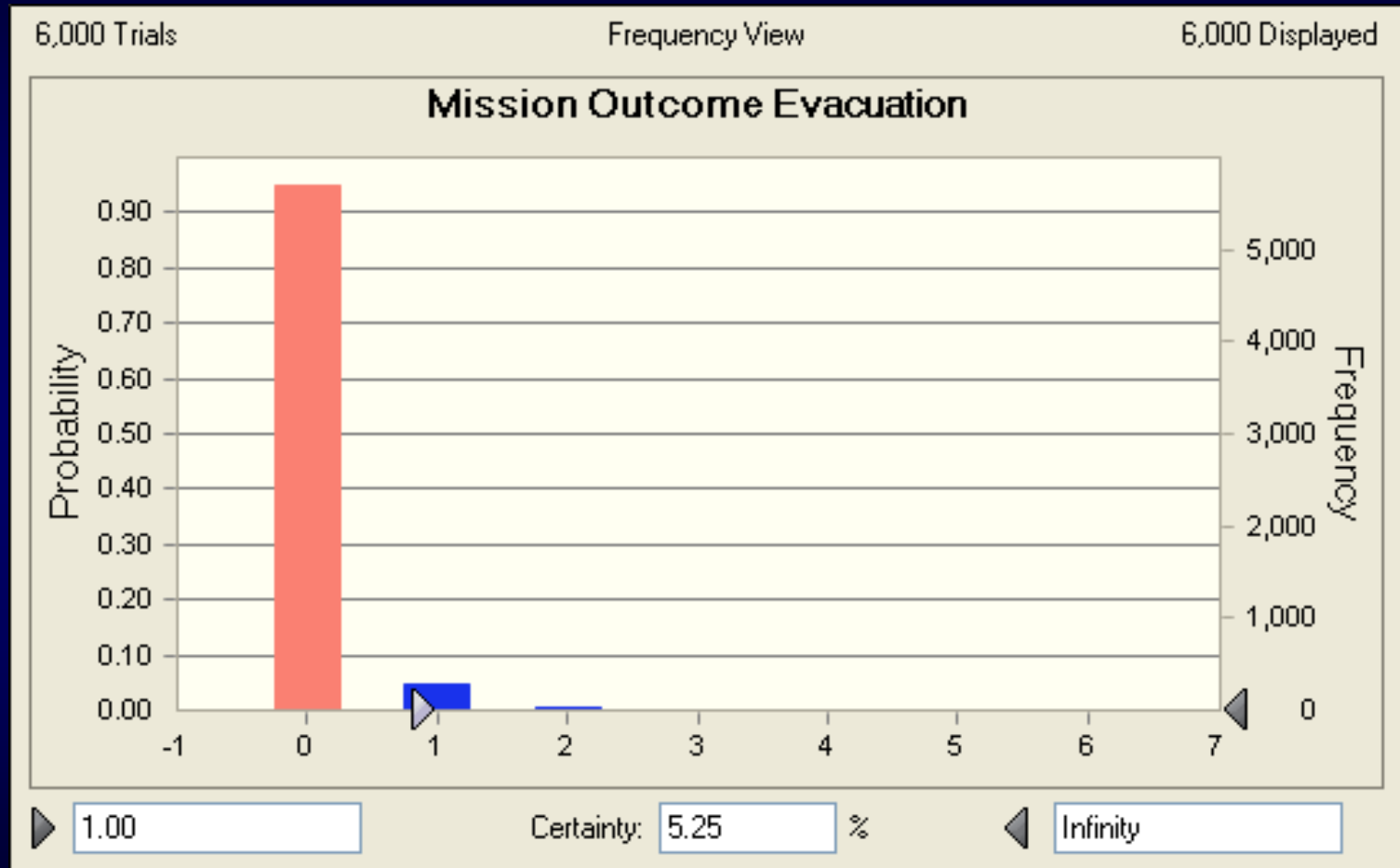
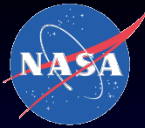
- Examine specific medical resources
 - Ibuprofen
- Alternative resource allocation
 - Increase supply for 6 crew, 6 month mission
- Shorter missions
 - 24 versus 33 day missions
- Vary number of crew members
 - 3 crew versus 4 crew

Alternative Outcomes



- Probability of evacuation
- Probability of loss of crew life
- Summary measures that combines CHI, EVAC, and LOCL?

Probability of EVAC



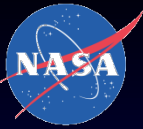
Information has not been validated.

Summary

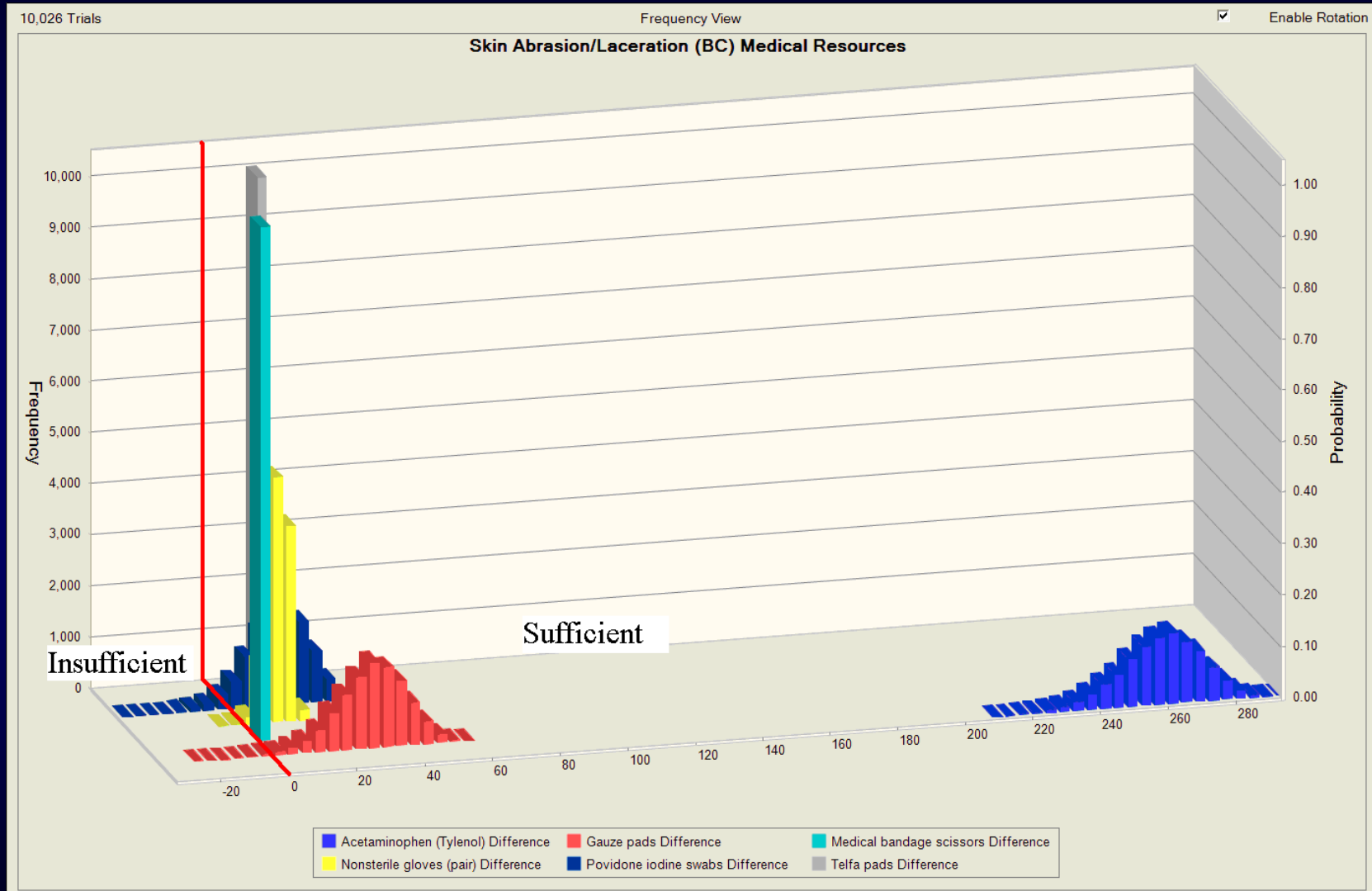
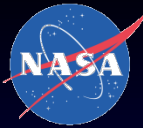


- IMM is a tool to assist in the decision making process
 - It does not make decisions
- IMM provides an objective analysis of likely medical events and outcomes during space flight
- IMM provides comparative analyses

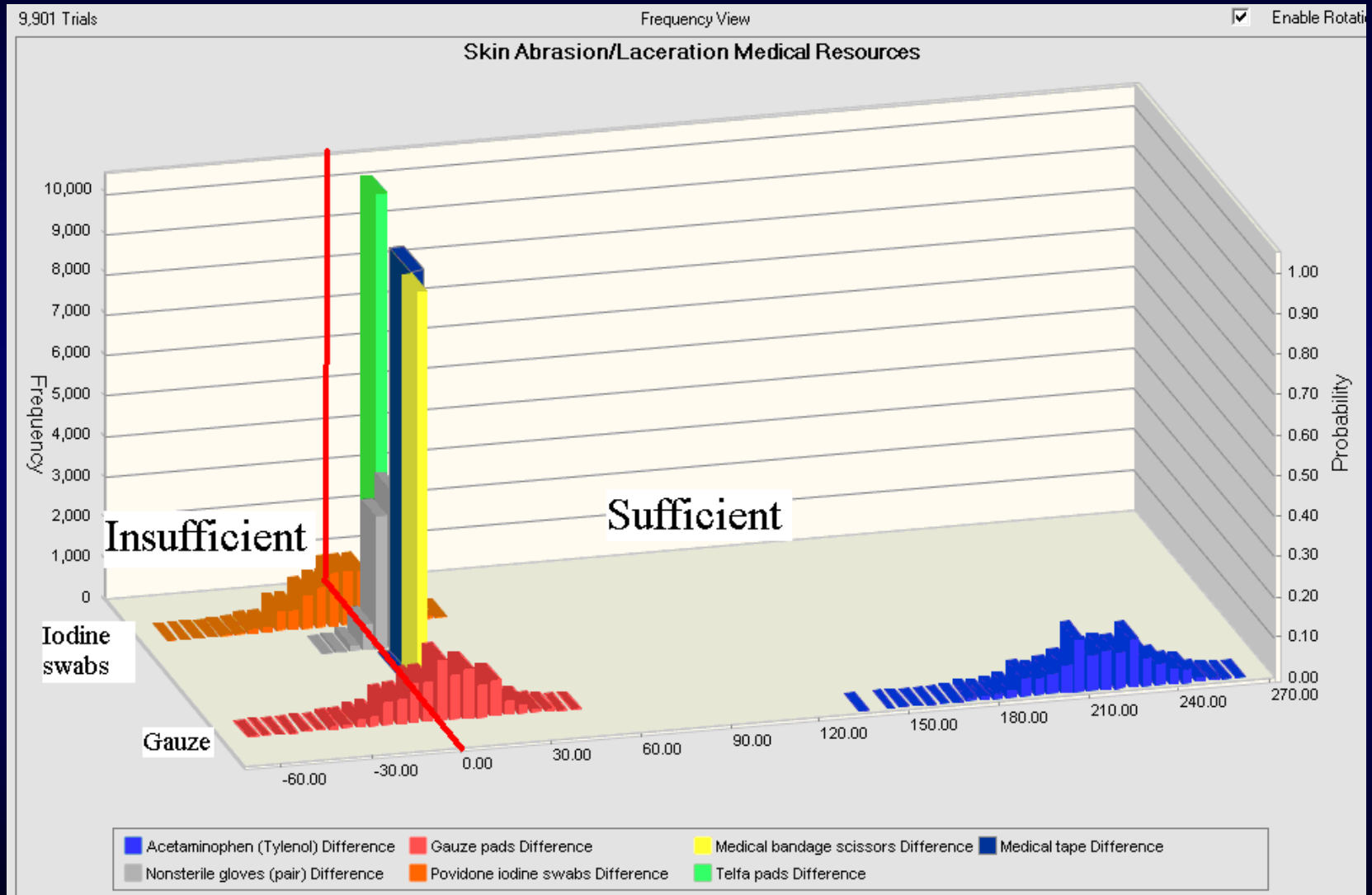
Questions?



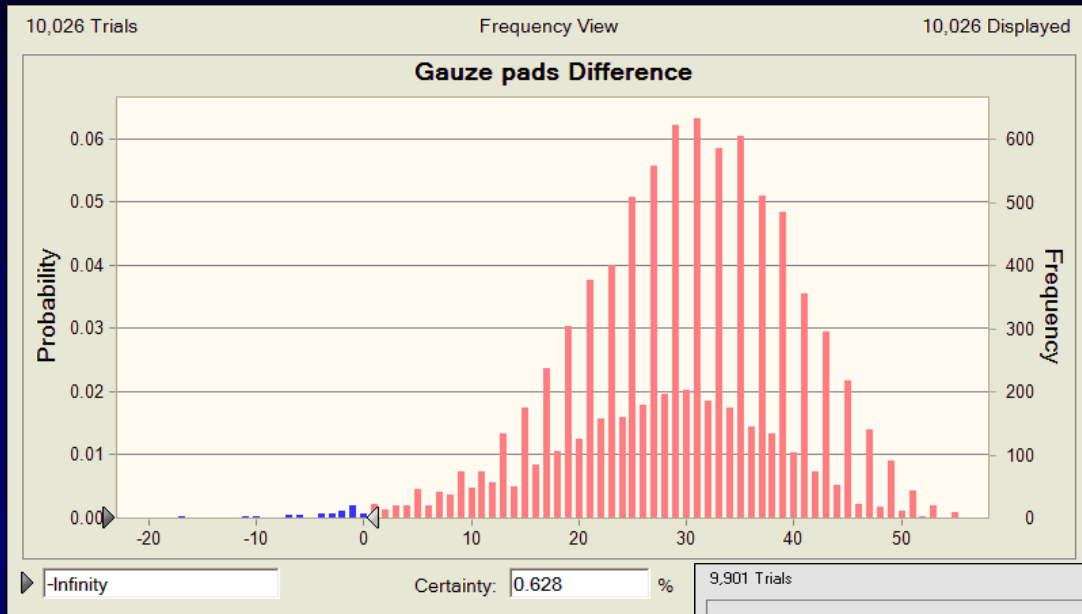
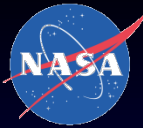
Skin Abrasion/Laceration Resources (3 Crew: Best Case only)



Skin Abrasion/Laceration Resources (6 Crew: Best Case only)

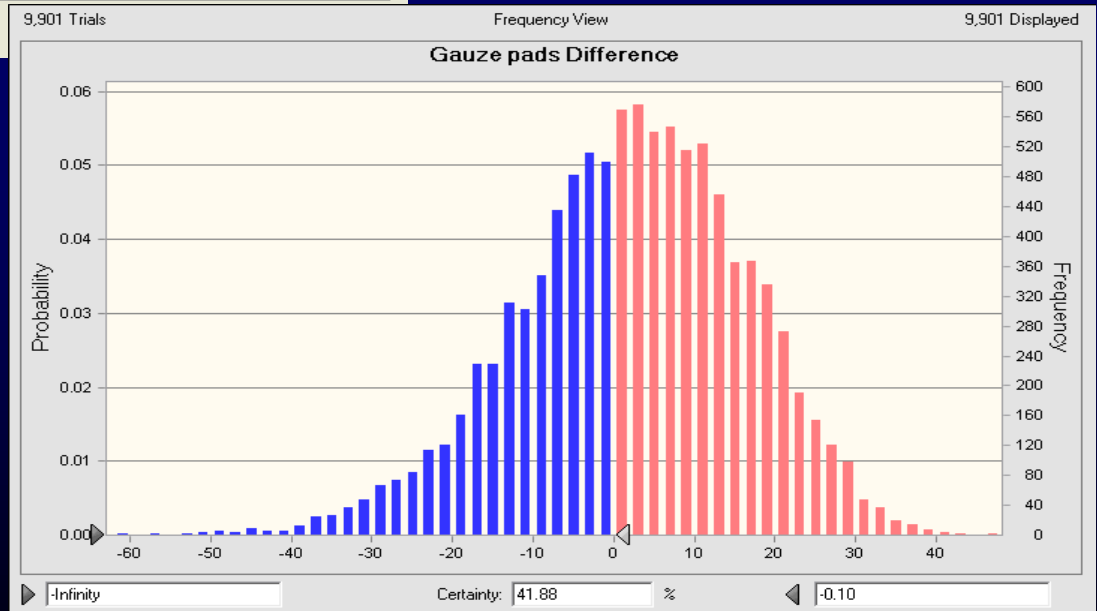


Gauze Pads

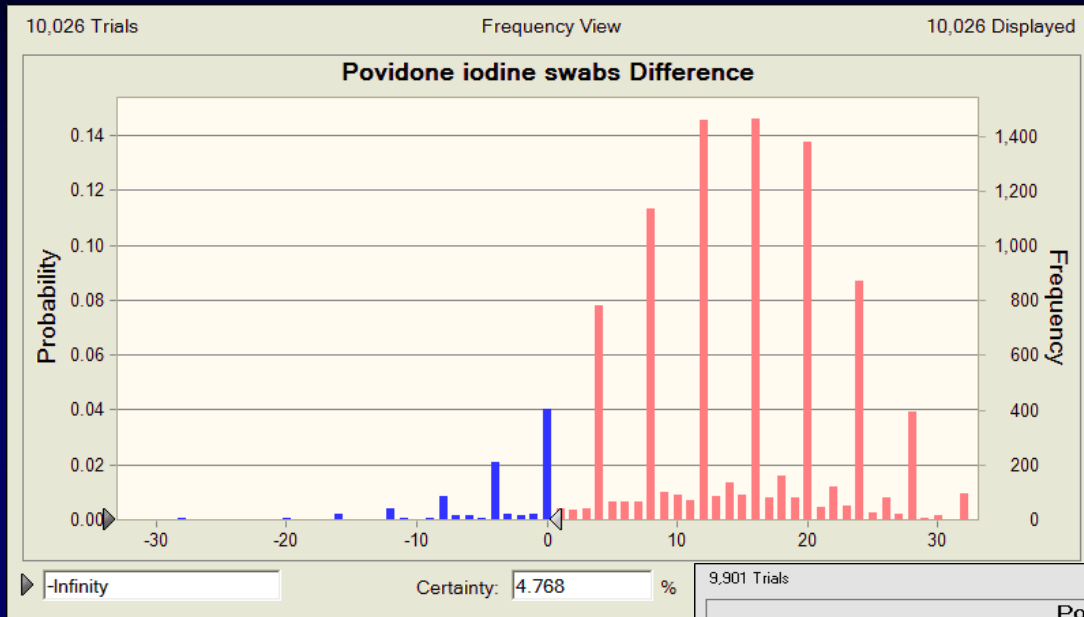


3 Crew Members
Insufficient for 0.6%
of the trials

6 Crew Members
Insufficient for 41.9%
of the trials

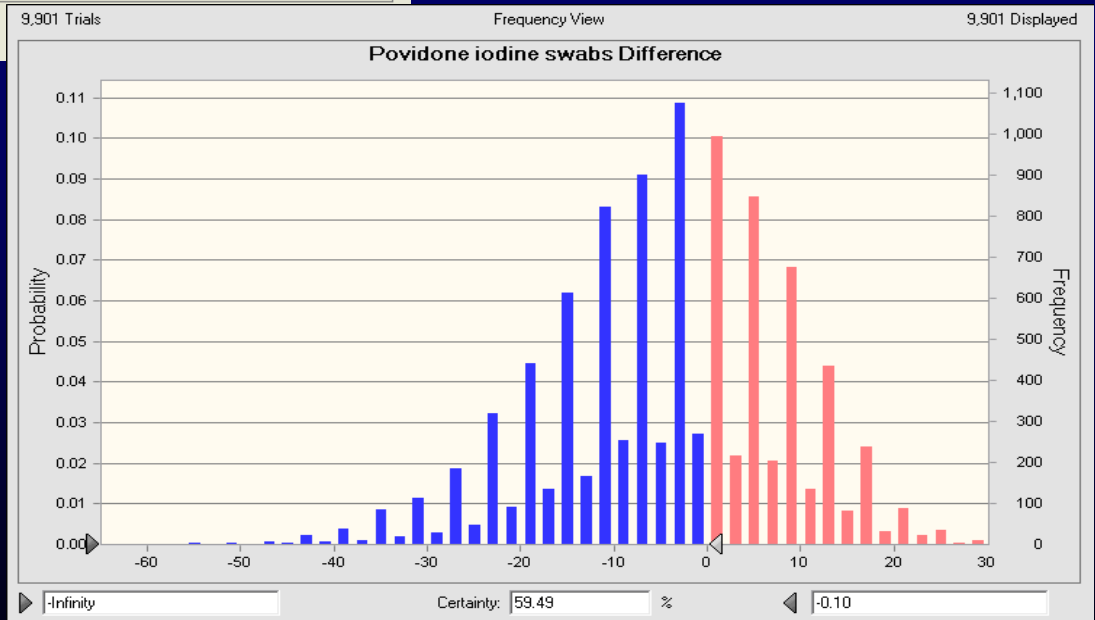


Povidone Iodine Swabs



3 Crew Members
Insufficient for 4.8% of
the trials

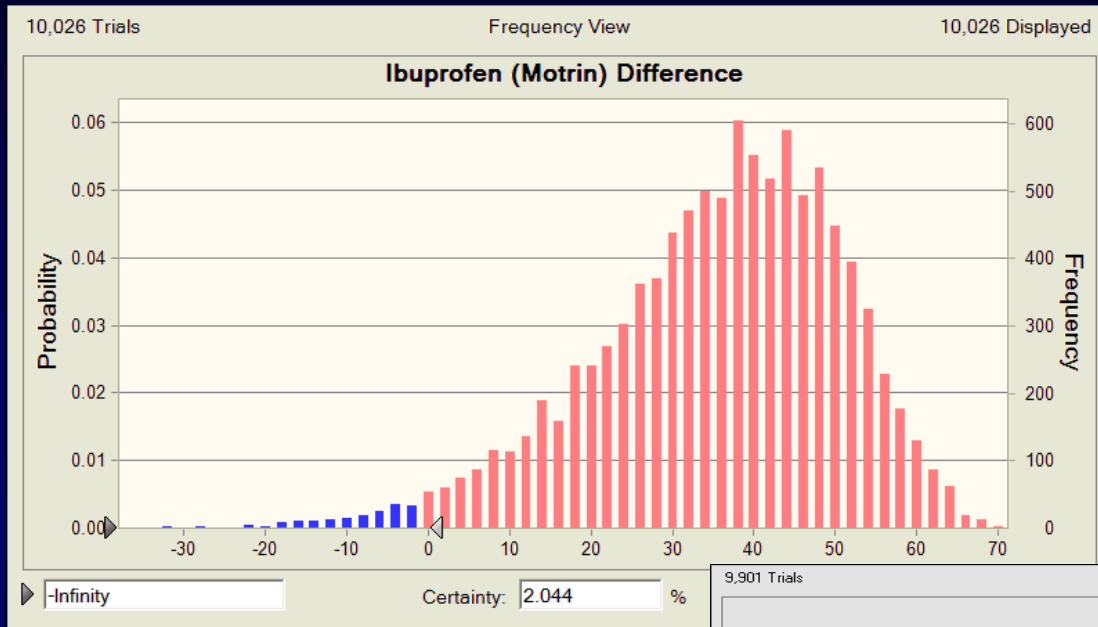
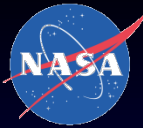
6 Crew Members
Insufficient for 59.5% of
the trials



- Compare Ibuprofen use
 - 3 crew, 6 months
 - 6 crew, 6 months
- What medical conditions explain the Ibuprofen usage?

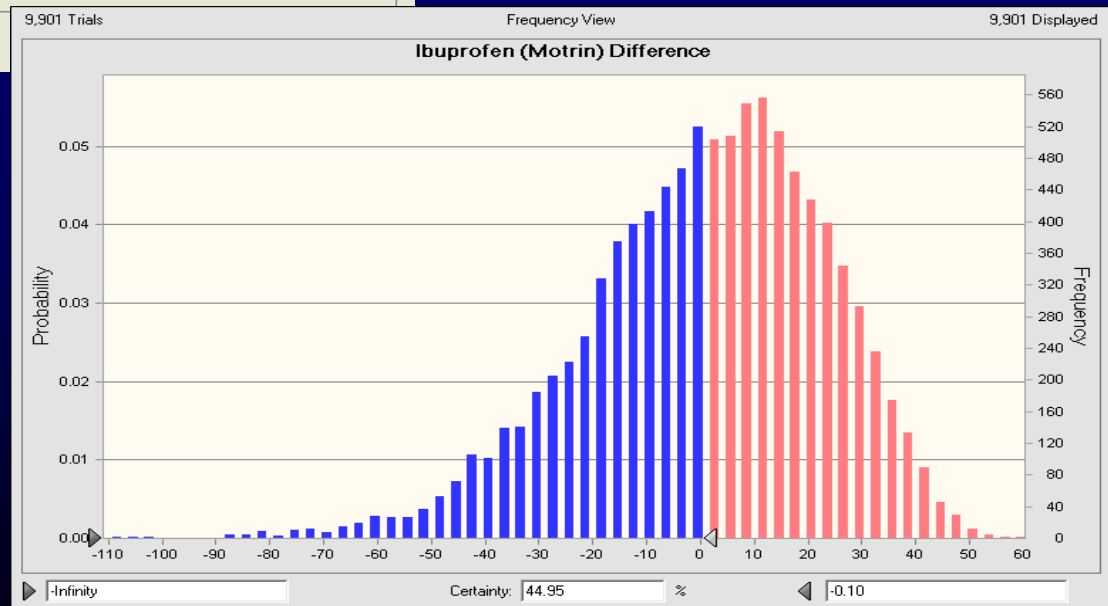


Ibuprofen (6 Month Mission)

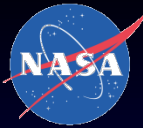


3 Crew Members
Insufficient for 2.0% of
the trials

6 Crew Members
Insufficient for 45.0% of
the trials



Ibuprofen Sensitivity Analysis



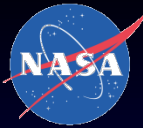
3 Crew Members

- 1) Back injury
- 2) Sprain/Strain - Shoulder
- 3) Paresthesia
- 4) Back pain (SAS)
- 5) Sprain/Strain – Elbow

6 Crew Members

- 1) Back injury
- 2) Sprain/Strain - Shoulder
- 3) Paresthesia
- 4) Back pain (SAS)
- 5) Sprain/Strain – Elbow

Increase Medical Resource Supply



- Will increasing the medical supplies increase the Crew Health Index?
- Double these resources for 6 crew member mission
 - Gauze pads
 - Povidone iodine swabs
 - Benadryl capsules
 - Ibuprofen
- Increases HMS requirement
 - 0.42 kg
 - 833.1 cm³
 - \$47.60

Crew Health Index



Current ISS Resources

Mean = 48.8%

Median = 49.2%

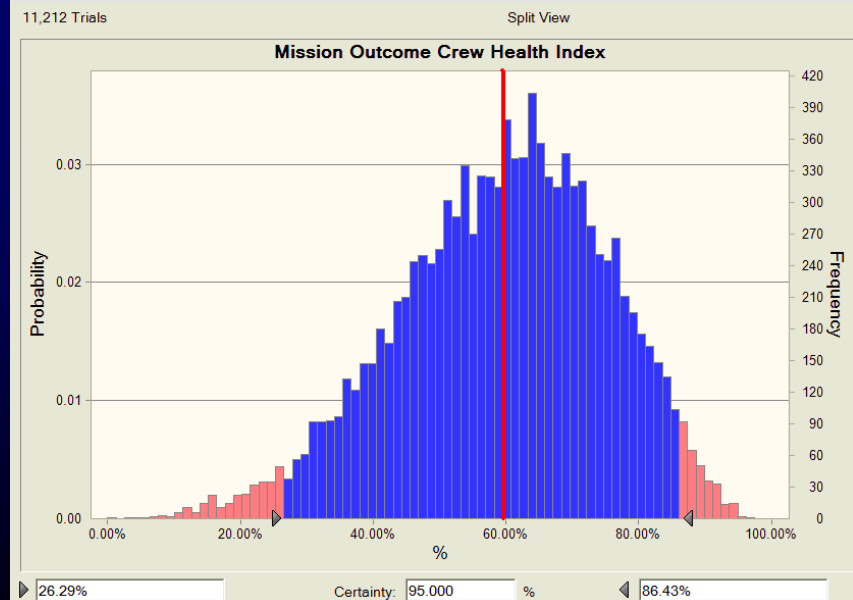
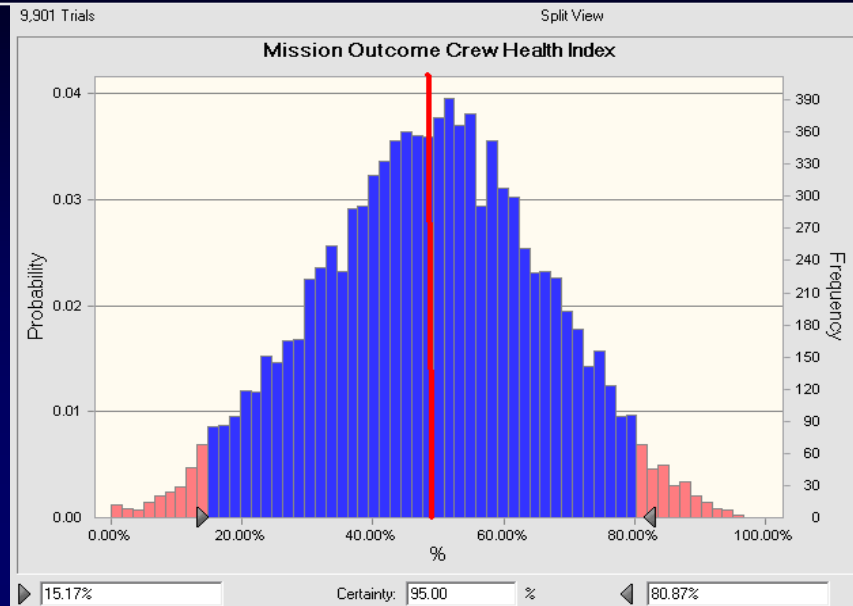
95% Inference: (15 – 81%)

Additional Resources

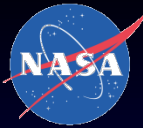
Mean = 59.4%

Median = 60.6%

95% Inference: (26 – 86%)



24 Day vs. 33 Day Missions

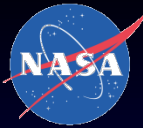


- Does a 33 day lunar mission require a different level of care than a 24 day lunar mission?



Variable	Mission 1	Mission 2
Mission length	24 Days	33 Days
# Crew	4 (3M, 1F)	4 (3M, 1F)
# EVAs/Person	4	5
Resources	ISS	ISS

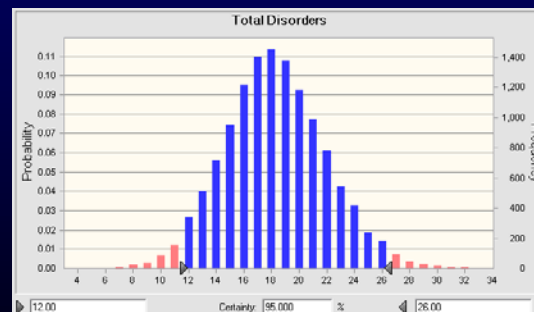
Total Medical Events



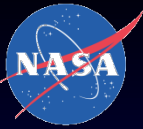
24 Days

33 Days

• Mean	18.3	21.0
• Median	18.0	21.0
• St. Dev.	3.6	4.0
• Minimum	4.0	5.0
• Maximum	33.0	38.0
• 95% Inference	12 - 26	13 - 29



Sensitivity Analysis



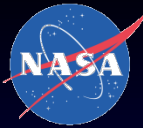
24 Day Mission

- Headache (SAS)
- Nasal congestion (SAS)
- Space motion sickness (SAS)
- Insomnia (SAS)
- Back pain (SAS)

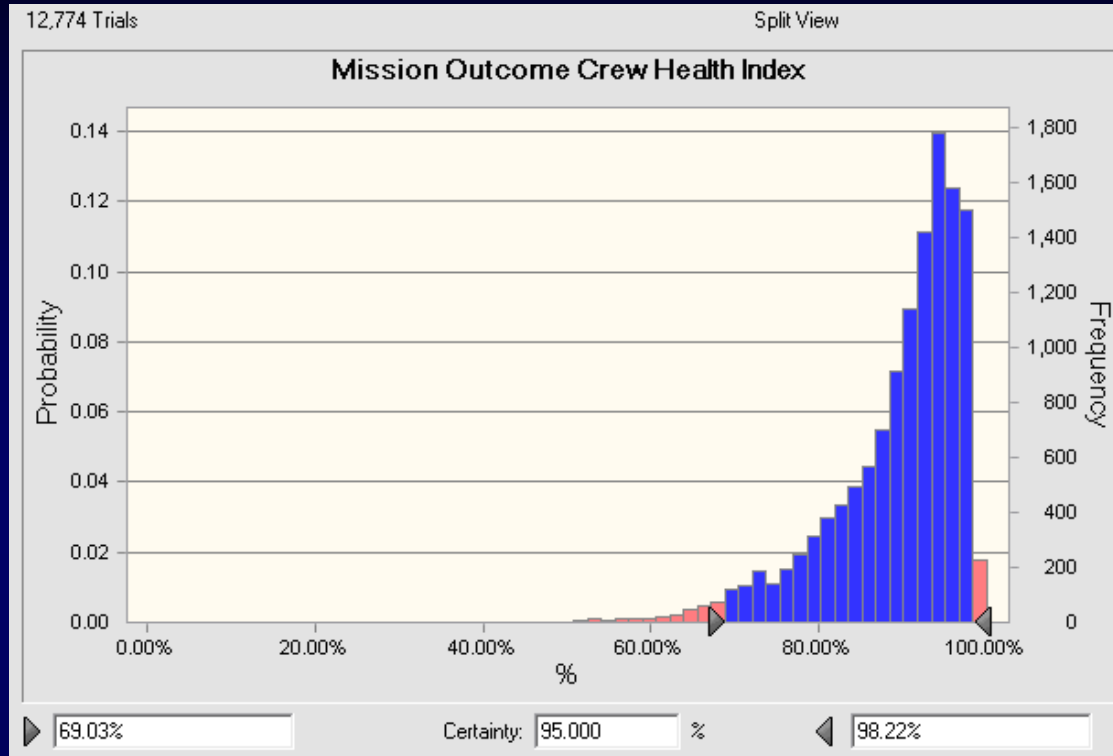
33 Day Mission

- Headache (SAS)
- Nasal congestion (SAS)
- Space motion sickness (SAS)
- Skin rash
- Late insomnia

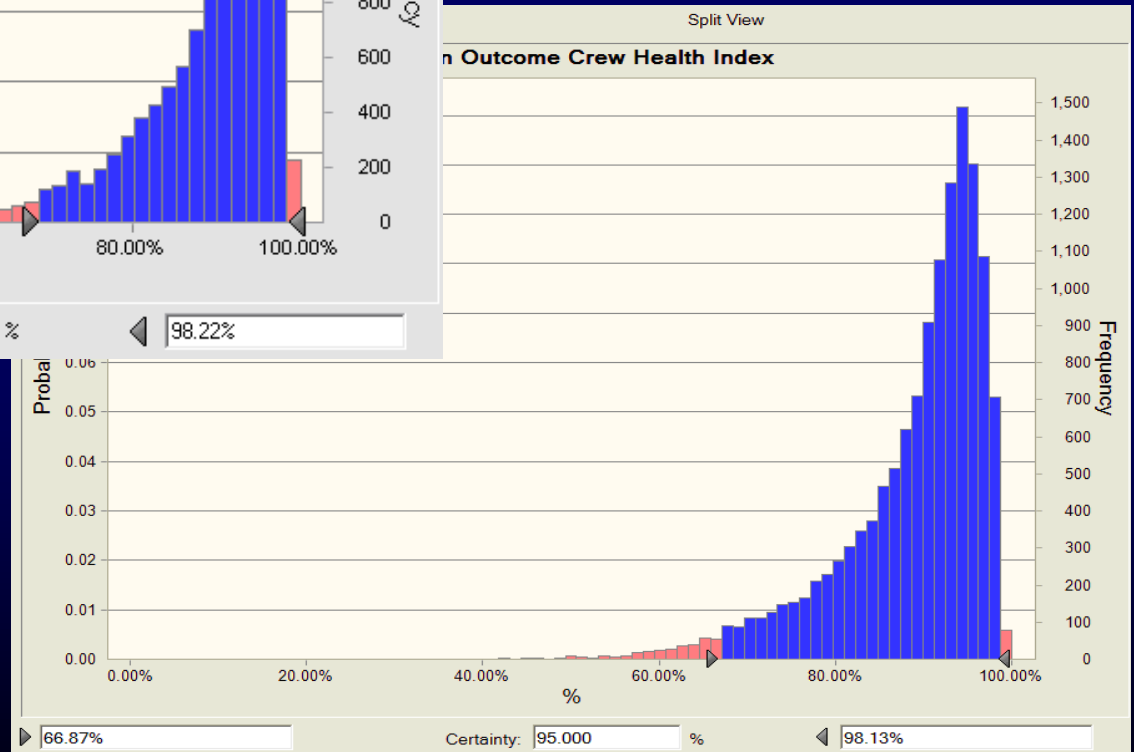
Crew Health Index



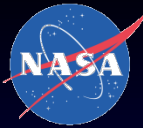
24 Day Mission



33 Day Mission



Crew Health Index



24 Days

- Mean 89.6%
- Median 92.0%
- St. Dev. 7.9%
- Minimum 50.0%
- Maximum 99.6%
- 95% Inference 69.0-98.2%

33 Days

- Mean 89.0%
- Median 91.6%
- St. Dev. 8.4%
- Minimum 26.8%
- Maximum 99.7%
- 95% Inference 66.9-98.1%

